

Apparently the accuracy which I have reached is rather less than Mr. Cooke's, but my results, I think, confirm his opinion as to the convenience of the method. I may add that the times which I have obtained by this method have only been needed for approximate purposes, but I believe them to be quite accurate. In May of the present year I received instructions to determine the latitude and longitude of Tema, and made my arrangements to obtain both latitude and accurate local time by the method ; but the telegraphic arrangements fell through, so that the method was only applied to the determination of latitude. I am convinced, however, that more accurate local times can be obtained in this way than by any other field method.

Relative Accuracy of Mr. Cooke's and other Methods.

It is interesting to inquire to what circumstance this method owes its supposed superiority over other field methods, including Talcott's. Given a faultless micrometer, Talcott's is a special case of Mr. Cooke's, and the one in which the error in zenith distance has the minimum effect on the latitude. If the superiority is confirmed, it would seem to imply that the accuracy of Talcott's method has hitherto been limited by micrometer errors.

My best thanks are due to Professor Turner for encouragement in this investigation, to the Survey Department of Egypt for providing facilities for the observations, and to the Under Secretary of State for Egyptian Public Works for permission to publish this note.

Abbasia Observatory, Egypt :
1903 October.

On the use of the Stereo-comparator for Plates on which a Réseau has been Impressed. By Dr. Max Wolf.

[*Introductory Note by Professor H. H. Turner.*—The accounts given of the ease and rapidity with which two plates of the same region can be compared with the stereo-comparator naturally create a desire to possess such an instrument. A generous offer has been made to present one to the Oxford University Observatory, *provided that it will clearly be of use in our work.* The very proper condition specified at once raises the question whether plates which have a réseau impressed upon them, and which have several images of the same star, can be scanned as readily by the stereoscopic method as those containing only a single image of each star and no réseau ; for all our plates accumulated hitherto at Oxford are of the former class. For some time I hoped to be able to obtain a stereo-comparator on loan to make

the experiment ; the makers (Messrs. Zeiss) courteously offered to put at my disposal for this purpose the first one available. But the demand for the instruments has been, I am glad to learn, so great, that hitherto they have been unable to do more than keep pace with it ; and ultimately I ventured to ask Dr. Max Wolf to make the experiments for me, which he very kindly consented to do. Two plates were sent him, both impressed with a *réseau*, and containing, the first three, and the second two, images of each star. They had been exposed for the planet *Eros*, and thus afforded material for tests of various kinds. It will be seen from the following letter that, even in this extreme case, the stereo-comparator can be used with advantage under certain conditions. The letter suggested that if *one* of the plates were free from a *réseau*, many of the difficulties would disappear, and this was found to be the case. A second pair of plates was sent to Heidelberg, one with a *réseau*, the other without, and a mere glance was sufficient to show Dr. Wolf that "there was now no trouble in observing two such plates with the stereo-comparator. The best position is to bring the chains of three stars in the line joining the eyes, and then it gives a splendid effect, so that the examination of the plates is easily made." In proof of which, Dr. Wolf remarked that there was a planet on one of the plates, and indicated its approximate position. The place was carefully measured when the plates were returned to Oxford, and the results—which seem to show that the planet was *Ausonia* (63)—have been communicated to the *Astronomische Nachrichten*. Hence, although it will be seen below that Dr. Max Wolf expresses himself rather doubtfully as to the value of the stereo-comparator for cases when both plates have a *réseau*, these doubts need not seriously concern us. For the instrument can be brought into effective use by taking a new plate without a *réseau*.

But Dr. Max Wolf's account of his experiments when both plates have a *réseau* will probably interest others ; and I therefore give it at full length.

I should add that Dr. Pulfrich of Jena also offered to make similar experiments, and another pair of plates was accordingly sent to him. His full account of the examination substantially agrees with Dr. Wolf's results. The *réseau* *disturbs* the examination, but does not *prevent* it—this is the verdict of both.

As a result of these experiments I felt justified in assuring Mr. C. L. Brook, F.R.A.S., who had made the generous offer above referred to, that the instrument would be most useful to us ; and he promptly purchased it for the Oxford University Observatory. It was on view at the R.A.S. rooms on November 27 and following days.]

DEAR PROFESSOR TURNER,—It is indeed a very difficult problem which you have set to me, and I can hardly give you advice whether to procure a stereo-comparator or not. Indeed,

a réseau makes the use of a stereo-comparator much more difficult than it is for our plates without réseau.

You have forwarded me two plates No. 1619 and 1620. No. 1619 contains of each star three images, No. 1620 two images :

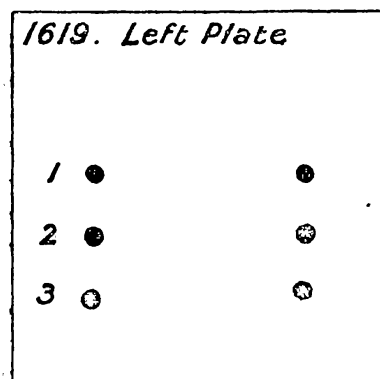


FIG. 1.

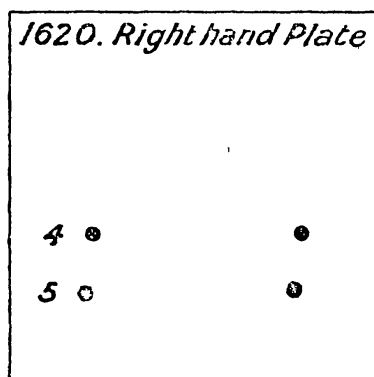


FIG. 2.

Now, if I put the two plates as seen here in the stereo-comparator and adjust the plates so that the middle images of 1619 coincide with the upper images of 1620 (viz. 2 with 4), then the star 1 comes out of the "infinity" plane and is close to the observer,* but the point 3 (combined with 5) approaches also to the observer, but not so much as the point 1, because the distance 2-3 is not equal to the distance 4-5.

So it happens that you see (of each star) always three images freely suspended in space : No. 1 very near to the observer, No. 2 at a very great distance far behind, and No. 3 at a mean distance between the two.

This appearance is preserved all over the plate if you move the two slides of the stereo-comparator ; you always see this beautiful roomy chain ; and at any place, where there is some trouble, you see it immediately by the change of this order.

On the two plates is also the planet *Eros*. Like all the stars he has made on 1619 three images, on 1620 two. Since some time has elapsed between the two exposures, the pictures do not coincide, but are situated at wholly different places. On each plate, therefore, the planet is seen immediately by the stereo-effect. On the plate with the three images *all three* points of *Eros* come far out of the ∞ plane and seem to be as near to the observer as points No. 1 of the stars. The same is with the left plate (I did not know the positions before).

In the same manner every wrong star is easily detected by the stereo-comparator. The stereo-effect is, of course, not necessary to detect faint stars, because all stars are threefold,

* There is, of course, no direct stereoscopic effect for an object which appears on one plate only ; but the appearance suggested is that of an object close to the observer.

and every spot only once upon the plate. But, notwithstanding, it is very comfortable to go over the plate using the slides of the stereo-comparator, and to feel the errors without thinking.

I am sorry that I could not detect a variable star on the plates, but there seems to be no variable.

Going over the plate I found the following wrong stars, which are all caused by holes in the réseau plate :

$x=15.5$:	$y=2.4$
25.8		10.8
0.8		10.5
20.4		11.2
21.6		13.7=(artificial cluster)
20.2		17.0
&c.		

These spots are on the two plates at the same places of the réseau, so that it is certain that they are holes in this.

So far as this, the stereo-comparator is of great value to find out changes in the stars and errors of the plates.

But now we come to the difficulty !

If the stereo-comparator is adjusted to the stars as above, the lines of the two réseaux fall tolerably separate ; and after practice for a day or so, one is accustomed to neglect the lines and to see the stars free in space on a distant indefinite network. If you look firmly upon the net then, you see the following view :

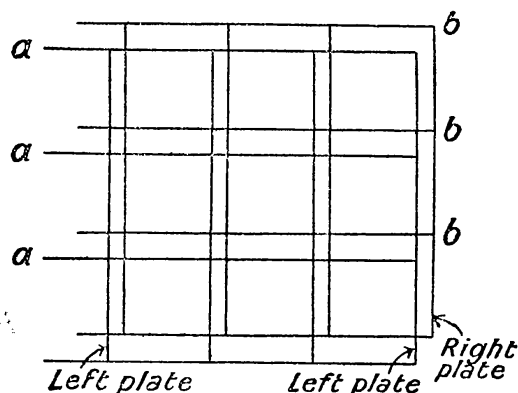


FIG. 3.

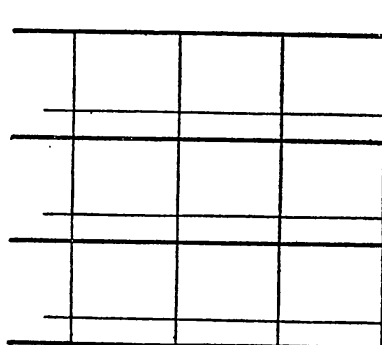


FIG. 4.

Fig. 3 gives the relative situation roughly of the two nets of the two plates, if the stars are adjusted as described above ; Fig. 4 gives the view seen with the two eyes by the stereo-comparator. We see the vertical lines join together, whilst the horizontal remain separated. This results from the situation of the two eyes, which are in a horizontal. The horizontal lines of

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the réseau of the left plate seem much thicker and somewhat nearer to the observer.

If starpoints 2 and 4 coincide over the whole plate, and if then the réseaux are adjusted absolutely parallel in the two

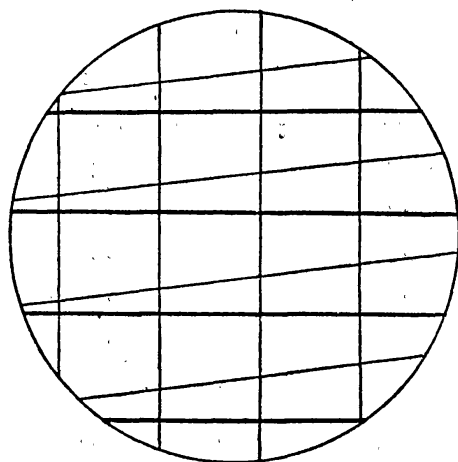


FIG. 5.

pictures, then we see in the stereo-comparator the horizontal lines not parallel to the eyes. It looks as if the lines *b* were inclined to the lines *a* (fig. 3). This is a very striking appearance. (Fig. 5 somewhat exaggerates the appearance.) The reason was found very soon. The connecting lines 1, 2, 3 and 4, 5 (figs. 1 and 2) are not parallel, and not parallel to the réseau. You see how the stereo-comparator can give the *errors of the orientation of your apparatus*.

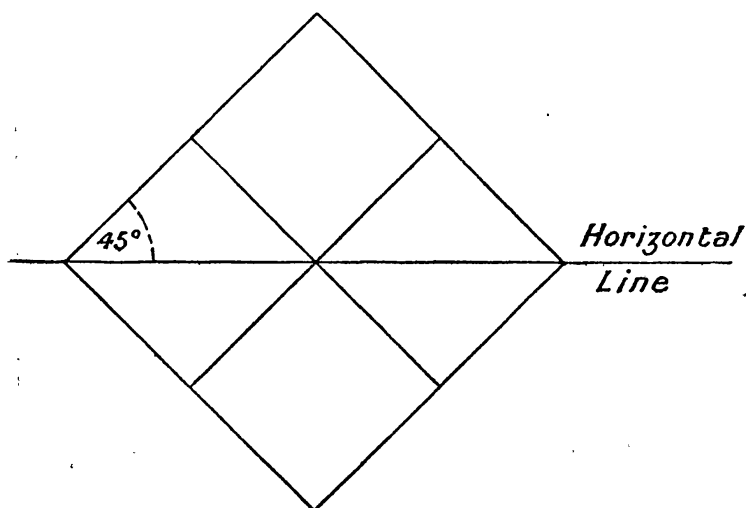


FIG. 6.

If we proceed to another adjustment of your plates we have still further difficulties. We will now put the two plates in the stereo-comparator, so that the lines of the réseau are inclined 45° to the connecting-line of your eyes (horizontal), fig. 6. If we

now adjust the plates so that the starpoints 2 and 4 coincide all over the plate, then all the lines join together in our mind, and we see only *one* net, *one* réseau ; but we cannot any longer see the stars coincident at the same time. By some effort it is possible to look firmly upon the stars, and to receive again the stereo-view of the stars. This is done most easily by moving the slides of the stereo-comparator and regarding the stars.

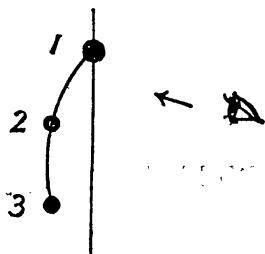


FIG. 7.

Point 1 is again very near to the observer.

2 very far distant.

3 lies nearer than at the first adjustment.

Eros seems very near to the observer. Pictures 3 and 5 of *Eros* seem very much nearer than the others.

The third position of the stereo-comparator was the following,

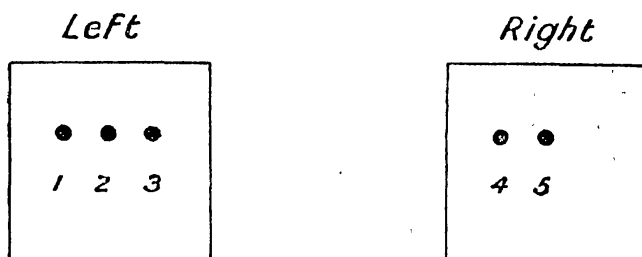


FIG. 8.

adjusting 2 upon 4 all over the plate. In this position picture 1 was still nearer to the observer, picture 2 still further, the effect a maximum, as natural. But now it was nearly impossible to seek over the plate and to fix the eyes upon the stars. At every moment the lines of the réseau will coincide in the eyes, and it is impossible for the eyes to hold upon the stars and to join the images of the stars in the mind.

Now you see the difficulty. If the two plates are so exposed that the lines fall *near* together when the stars are in coincidence, then the eyes are unable to hold the lines from together and to join the stars. If, on the other hand, the plates are so exposed that the lines are *far* from together, regarding the same starpoints, then the stereo-comparator is *very* useful and easily applied for the research of the plates.

You see also from the above that for these two plates, 1619 and 1620, there was one position which was useful ; and it is not impossible that on a great part of your plates you will be able to find one position for stereo-comparing work.

Now you can imagine how difficult it is for me to bear the responsibility to give you advice whether to procure a stereo-comparator or not. There is no doubt you will not have the full benefit of the instrument, because in many cases the réseau makes the use of the stereo-comparator impossible ; on the other hand, in many cases you will have some great *profit* of its use.

Excuse me that I can give you no deciding answer, but the reason lies not in my hands, it reposes on the difficulty of the matter.

With kind regards, yours very truly,
MAX WOLF.

Heidelberg: 1903 July 5.

An Examination of the Relative Star-density in Different Parts of the Plates forming the Harvard Photographic Sky-map. By J. C. W. Herschel, B.A.

In *Monthly Notices*, lxii. 1902 April, p. 444, Professor Turner gave diagrams for five different observatories, which use essentially similar objectives, showing that the relative number of star images photographed in different parts of a plate varies by about 50 per cent., and can be expressed in terms of the distance from the centre ; there is no continuous area of useful uniformity ; on the other hand, he showed that the *doublet* used for the C.P.D. gives a sensibly uniform field over $6^{\circ} \times 6^{\circ}$.

Professor Pickering has recently issued a set of fifty-five photographs taken with a doublet as "a photographic map of the entire sky" (*Harvard Circular*, No. 71), being picked plates chosen out of those with which a continuous watch has been kept upon the sky at Harvard College and Arequipa for many years.

It seems useful, therefore, to ascertain whether any considerable area of *these* plates has reasonable uniformity of star-density, and if so to what extent.

I am indebted to Professor Turner for suggesting this question, and for the use of the set of plates at the Oxford University Observatory.

The photographs were taken with a portrait lens of one inch aperture and thirteen inches focal length, and they cover about 30° square. Twelve plates (Nos. 1, 2, 6, 10, 16, 22, 28, 34, 40, 46, 50, and 54) were chosen, to cover an entire belt of the sky passing through the poles and cutting the Milky Way nearly at right angles ; in fact, the plate centres lie along the equinoctial colure, at declinations $+60$, $+30$, 0 , -30 , -60 , on both the 0^h and xii^h